(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 140 246**
**A1**

# (12) EUROPEAN PATENT APPLICATION

(21) Application number: 84112241.9

(51) Int. Cl.⁴: H 05 B 33/22

(22) Date of filing: 11.10.84

(30) Priority: 11.10.83 US 540223

(43) Date of publication of application:
08.05.85 Bulletin 85/19

(84) Designated Contracting States:
BE DE FR GB NL

(71) Applicant: GTE Products Corporation
100 West 10th Street
Wilmington, DE 19801(US)

(72) Inventor: Schrank, Martin P.
25 Howe St.
Ipswich, MA 01938(US)

(72) Inventor: Ayyagari, Murthy S.
45 Mt. Vernon St.
North Reading, MA 01864(US)

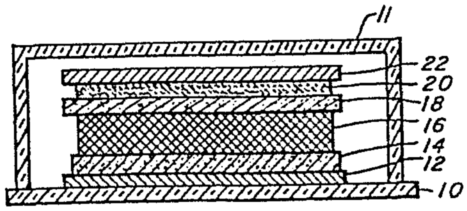
(72) Inventor: Shinn, Dennis B.
28 Colrain Rd
Topsfield, MA 01983(US)

(74) Representative: Patentanwälte Grünecker, Dr. Kinkeldey, Dr. Stockmair, Dr. Schumann, Jakob, Dr. Bezold, Meister, Hilgers, Dr. Meyer-Plath
Maximilianstrasse 58
D-8000 München 22(DE)

## (54) A thin film electroluminescent display device.

(57) A thin film electroluminescent display device comprising a transparent electrode layer, a segmented electrode layer, an electroluminescent phosphor layer between the electrode layers, and an improved dark field material disposed as a layer between the phosphor and segmented electrode layers. The improved dark field layer is of a composition of a dielectric material, such as the preferred magnesium oxide, and a noble metal, which in the preferred version is gold. These materials comprising the dark field composition may be co-evaporated by an electron beam evaporation or other suitable deposition technique. The composition of dark field material provides for contrast enhancement is non-toxic, and is readily analyzable.

*Fig. 1*




EP 0 140 246 A1

A THIN FILM ELECTROLUMINESCENT DISPLAY DEVICE

BACKGROUND OF THE INVENTION

The present invention relates in general to a thin film electroluminescent display device and is concerned, more particularly, with an improved dark field material for such a thin film electroluminescent display device.

Electroluminescent devices generally comprise a phosphor layer disposed between two electrode layers with one of the electrodes being transparent so as to permit viewability of the phosphor layer. It is known to provide a dark field layer behind the phosphor layer in order to improve the contrast ratio of the device when using a segmented back electrode layer; that is to say, to provide visibility of the phosphor layer overlying the back electrode segments even under ambient conditions of high brightness. See U.S. Patent 3,560,784 for an example of a dark field layer, the material of which may comprise arsenic sulphide, arsenic selenide, arsenic sulfoselenide or mixtures thereof. However, these arsenic compounds either do not provide a satisfactory dark color or they change color during use.

Perhaps the most common dark field material presently being used is cadmium telluride (CdTe). Although the CdTe layer provides for enhancement in contrast between the displayed information and the background, one of the problems associated with the CdTe composition is that it is toxic and the material does not meet safety specifications for commercial products as required by OSHA (Occupational Safety and Health Act).

One solution to this toxicity problem is described in copending application U.S. Serial No. 262,097, filed May 11, 1981 and assigned to the present assignee, which defines an electroluminescent device having a dark field layer comprising a cermet of chromium oxide - chromium ($Cr_2O_3/Cr$). Although overcoming the toxicity problem, this cermet comprises a combination of a metal (Cr) and an oxide ($Cr_2O_3$) of the same base metal, thereby rendering the dark field composition difficult, if not impossible, for analysis of the constituent proportions. Such analysis is important to enable precise control of the constituent proportion for providing optimum results.

Accordingly, it is an object of the present invention to provide an improved electroluminescent display device and in particular an improved dark field material for such a device.

Another object of the present invention is to provide an improved dark field in accordance with the preceding object and which is characterized by an improved contrast ratio of the device.

Still another object of the present invention is to provide a dark field material in accordance with the preceding objects and which is non-toxic and meets the safety specifications for commercial products required by OSHA.

A further object of the present invention is to provide an improved dark field layer in a thin film electroluminescent display device in which for at least some applications, only a single transparent dielectric layer of the device is employed in comparison with the typical first and second transparent dielectric layers used in the past in electroluminescent thin film display devices.

Still a further object of the present invention is to provide an improved dark field material for a thin film electroluminescent display device in which the dark field layer is formed of constituents which are readily analyzable, and thus precisely controllable, to provide enhanced flexibility in controlling parameters of the dark field layer such as contrast ratio.

## SUMMARY OF THE INVENTION

To accomplish the foregoing and other objects of this invention, there is provided an improved dark field material for a thin film electroluminescent display device, which display device typically comprises an electroluminescent phosphor layer disposed between two electrode layers with one of the electrodes being transparent to permit viewability of the phosphor layer. The improved dark field layer in accordance with the present invention comprises a composition of a dielectric material, preferably a ceramic, in combination with a noble metal, which in the preferred embodiment is gold. The ceramic is preferably magnesium oxide. The preferred composition of magnesium oxide and gold may be formed by a sputtering technique, examples of which are described in further detail hereinafter.

## BRIEF DESCRIPTION OF THE DRAWINGS

Numerous other objects, features and advantages of the invention should now become apparent upon a reading of the following detailed description taken in conjunction with the accompanying drawing, in which:

FIG. 1 is a schematic cross-sectional view showing the multiple layers of a thin film electroluminescent display device including the dark field layer of this invention; and

FIG. 2 is a schematic cross-sectional view showing an alternative construction of the thin film electroluminescent display device showing a single transparent dielectric layer rather than the two dielectric layers depicted in FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENT

In accordance with the present invention, the dark field material for a thin film electroluminescent display device is formed by a composition of a dielectric material with a noble metal. The dark field layer serves the basic purpose of enhancing the contrast between the displayed information which is usually in segment form and the background. In order to eliminate the prior art problem associated with CdTe dark field layers, which are toxic, and yet provide suitable analyzability of the dark field composition, it has been found in accordance with the present invention that a composition of, for example, magnesium oxide and gold which are co-evaporated, preferably by an electron beam technique, provide a dark field material that is non-toxic, is readily analyzable and meets the safety specifications for commercial products. A layer of such material has not previously been employed at all in the construction of electroluminescent display devices, although, a MgO/Au film has been previously evaluated as a solar absorbing material for solar panels. In this regard, see U.S. Patent 4,312,915; also see the article by Fan and Zavracky, Applied Physics Letters, Volume 29, No. 8, 15 October, 1976, page 478-480. Also see the article by Berthier and Lafait in Thin Solid Films 89 (1982) 213-220 entitled "Optical Properties of Au-MgO Cermet Thin Films: Percolation Threshold and Grain Size Effect". The latter article is concerned primarily with the method of deposition and associated optical properties.

In addition to the advantage of non-toxicity of the composition of this invention, the layer has also been found to unexpectedly provide contrast enhancement.

With reference to the drawing, it is noted that in FIG. 1 there is shown a version of an electroluminescent display device incorporating the dark field of this invention. In FIG. 2, one of the two transparent dielectric layers shown in FIG. 1 has been removed because, in accordance with the present invention, the improved dark field layer also functions as a substitute for one of the dielectric layers. In other words the dielectric/noble metal composition serves both as the dark field and as the second dielectric.

In FIGS. 1 and 2, like reference characters are used to identify like layers of each embodiment disclosed. Thus, there is shown a glass substrate 10 on which are formed a number of multiple thin-film layers, which may be enclosed by a glass seal 11. These layers include a transparent electrode 12, a first transparent dielectric layer 14, an electroluminescent phosphor layer 16, a second transparent dielectric layer 18, a dark field layer 20, and a back segmented electrode 22. In FIGS. 1 and 2 the transparent dielectric layers may be of yttria, and the electroluminescent phosphor layer may be of, for example, zinc sulphide. In the embodiment of FIG. 1, the second transparent dielectric layer 18 is shown, but it is noted that in the embodiment of FIG. 2, this layer is not present. The dark field layer 20 in FIG. 2 instead serves both as the dark field and as the second dielectric layer.

The composition of the dark field layer 20, which in its broadest sense comprises a dielectric material, preferably a ceramic, and a noble metal, preferably gold, may be deposited by co-evaporation using standard deposition techniques. In accordance with one technique, co-evaporation is used with e-beam equipment. The evaporation may take place in one chamber of a two-chamber system. The two chamber system has two e-beam guns, each with its own power supply. In the preferred version, magnesium oxide may be in pellet form and loaded into one crucible, and gold is disposed in the second crucible. The deposition may be measured by means of conventional crystal monitors. One crystal monitor is placed over each crucible being disposed as close as possible to the position where the substrate is. The co-evaporation technique using separate crucibles is carried out in a vacuum of preferably better than $1 \times 10^{-5}$ torr. The volume percentage of gold is varied with the gold concentration preferably in the range of 6%-10% by volume.

The percentage of gold in the composition is instrumental in controlling the resistivity of the cermet. With regard to the control of gold (noble metal) concentration, reference is now made to a co-pending application Serial No. (attorney's docket No. 22,429) filed of even date herewith and assigned to the present assignee.

In one test that was carried out, the dark field layer had a thickness of 0.5 micron. The preferred film thickness is in the range of 5000-9000 Angstroms. The lateral resistance between back electrode segments is on the order of 10 megohms while the perpendicular resistance across the film thickness is on the order of 1K ohm or less. A contrast ratio of 2:1 is measured at an ambient light level of 2500 foot-candles with the back electrode segments at 160 volts and 60 foot-lamberts. With those parameters, display devices have been operated successfully up to 500 hours of operating time.

With regard to measurements of contrast between the displayed information and the background, such measurements have been taken by shining a Sylvania Sun-Gun lamp at the lighted and unlighted display segments. The Sun-Gun lamp was set at an output of 3500 foot-candles. In two different respective devices that were tested, the contrast ratio measured was 4.2 and 5.3, respectively.

In accordance with another technique for forming the dark field layer, sputtering may be used in a reactive atmosphere of say argon and oxygen in a ratio of 70%-30%, respectively.

One of the primary advantages of the composition MgO/Au is that the material itself as well as the process forming it, is non-toxic. Also, the admixed metal (Au) and the metal of the metal oxide (Mg) are two different materials and thus the ratio between these constituents is readily analyzable and, thus, provides for an added degree of control over such parameters of the dark field layer as electrical conductivity and optical absorption.

Reference has been made to the preferred layer construction of magnesium oxide and gold. However, it is understood that in accordance with other embodiments of the invention the composition may comprise other noble metals in place of the gold such as platinum or silver. The dielectric portion of the composition may be a ceramic. This can be a metal oxide or a metal nitride (such as aluminum nitride) or can even be a semiconductor such as silicon dioxide or germanium dioxide. The noble metal portion of the composition is in the form of a relatively stable metal thus not tending to react with the metallic in the ceramic portion of the composition. The noble metal, such a gold does not readily oxidize if it is mixed with the magnesium oxide.

Having now described a limited number of embodiments of the present invention, it should now be apparent to those skilled in the art that numerous other embodiments are contemplated as falling within the scope of this invention as defined by the appended claims, for example, the dark field layer may be deposited by techniques other than co-evaporation or electron beam evaporation, such as by sputtering.

What is claimed is:

CLAIMS

1. An electroluminescent display device comprising a transparent electrode layer, a segmented electrode layer, an electroluminescent phosphor layer disposed between said electrode layers, and a dark field layer of a composition of a dielectric material with a noble metal, said dark field layer being interposed between said electroluminescent phosphor layer and said segmented electrode layer.

2. An electroluminescent display device as set forth in claim 1 including only a single transparent dielectric layer adjacent the electroluminescent phosphor layer.

3. An electroluminescent display device as set forth in claim 1 wherein the dark field layer has a film thickness in the range of 5000-9000 Angstroms.

4. An electroluminescent display device as set forth in claim 1 wherein the device has a contrast ratio of at least 2:1.

5. An electroluminescent display device as set forth in claim 1 wherein the composition of the dark field layer is deposited by co-evaporation from separate sources.

6. An electroluminescent display device as set forth in claim 1 wherein the noble metal comprises gold.

7. An electroluminescent display device as set forth in claim 1 wherein said dielectric material of the dark field layer comprises a metal oxide.

8. An electroluminescent display device as set forth in claim 7 wherein said metal oxide comprises magnesium oxide.

9. An electroluminescent display device as set forth in claim 1 wherein said dielectric material of the dark field layer comprises silicon dioxide.

10. An electroluminescent display device as set forth in claim 1 wherein said dielectric material of the dark field layer comprises germanium dioxide.

11. An electroluminescent display device as set forth in claim 1 wherein said dielectric material of the dark field layer comprises aluminum nitride.

12. An electroluminescent display device as set forth in claim 1 wherein said dielectric material of the dark field layer is comprised of a metal oxide, a metal nitride or a semiconductor.

1/1

Fig. 1

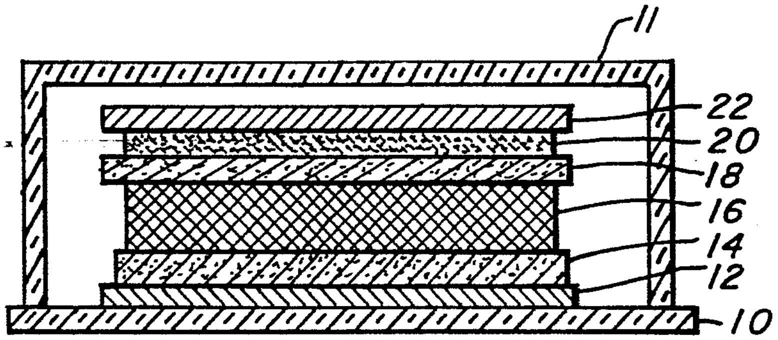
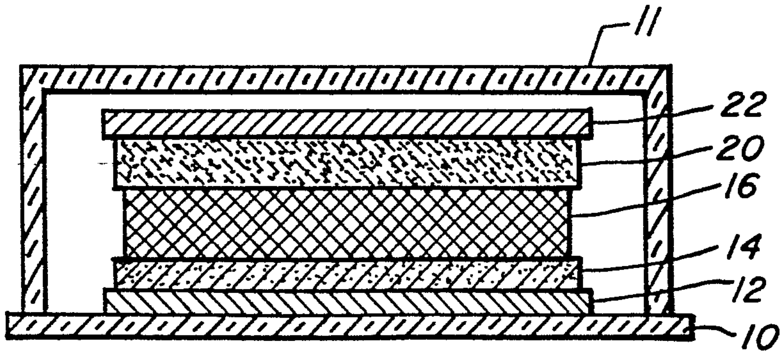



Fig. 2



European Patent Office

# EUROPEAN SEARCH REPORT

0140246
Application number

EP 84112241.9

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.4) |
|---|---|---|---|
| A | GB - A - 2 039 146 (GTE SYLVANIA) * Abstract; fig. 1 * -- | 1 | H 05 B 33/22 |
| A | GB - A - 2 109 161 (SHARP) * Abstract; fig. 1; claims 1-7 * -- | 1 | |
| A | DE - A1 - 3 114 199 (OSAKEYHTIÖ) * Abstract; fig. 2 * -- | 1 | |
| D,A | US - A - 4 312 915 (FAN) * Abstract; claims 1-24; fig. 7-9 * -- | 1 | **TECHNICAL FIELDS SEARCHED (Int. Cl.4)** |
| D,A | US - A - 3 560 784 (STEELE) * Abstract; fig. 2 * -- | 1 | H 05 B 33/00<br>H 01 L 33/00<br>B 32 B 5/00<br>H 01 J 29/00 |
| D,A | THIN SOLID FILMS, vol. 89, no. 2, March 12, 1982, Elsevier Sequoia, Netherlands<br>S. BERTHIER "Optical properties of Au-MgO Cermet Thin Films: Percolation Threshold and Grain Size Effect"<br>pages 213-220<br>* Totality * -- | 1-12 | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| VIENNA | 10-01-1985 | VAKIL |

**CATEGORY OF CITED DOCUMENTS**

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO Form 1503. 03.82

European Patent Office

# EUROPEAN SEARCH REPORT

0140246
Application number
EP 84112241.9

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.4) |
|---|---|---|---|
| D,A | APPLIED PHYSICS LETTERS, vol. 29, no. 8, October 15, 1976, Massachusetts, U.S.A.<br>FAN, ZAVRACKY "Selective black absorbers using MgO/Au cermet films" pages 478-480<br>* Totality *<br>---- | 1-12 | |
| | | | TECHNICAL FIELDS SEARCHED (Int. Cl.4) |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| VIENNA | 10-01-1985 | VAKIL |

**CATEGORY OF CITED DOCUMENTS**

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document
T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document